CLIMATIC GASES RELEASED FROM THE CHICXULUB IMPACT

J. V. Morgan[1], N. A. Artemieva[2,3], and Exedition 364 Science Party[4], [1]Imperial College London, Dept. Earth Science and Engineering, London, UK, SW7 2AZ, j.morgan@imperial.ac.uk, [2]Planetary Science Institute, 1700 E. Fort Lowell Road, Suite 106, Tucson, AZ 85719, USA, [3] Institute for Dynamics of Geospheres, Moscow, 117979, Russia.

Introduction: The cause of the K-Pg mass extinction remains a matter of some debate. Here, we revisit the release of climatically-active gases by the Chicxulub impact, which was a principal objective of IODP-ICDP Expedition 364: drilling the K-Pg impact crater. Previous estimates were hindered by: 1) not knowing the angle and direction of impact; 2) limited data on the composition of the target rock at the impact site; 3) limits in computational power; and 4) unreliable equations of state (EOS) including the shock pressures at which sedimentary rocks decompose and release gases during shock devolatilization [1-2]. There have been improvements in the EOS for quartz [3] and there is new evidence for the direction (downrange to the southwest) and angle of impact (~60 degrees) [4], which leads to better constraints on which sedimentary rocks were shock devolatilzed and ejected. In addition, improvements in the hydrocode SOVA and computational power mean that we can model the ejection from the impact site at a higher resolution, and for sufficiently long times to determine the proportion of degassed sedimentary rocks ejected to sufficiently high altitudes (> 25 km) to have had global consequences.

Method: We use the multi-phase hydrocode SOVA [5] which is a 3D Eulerian code that has the capability to simulate the dynamics of different materials within the impact plume. We use an impact angle of 60 ±10 degrees, in accordance with new 3D simulations of an oblique impact [4], an impact velocity of 18 km/s, projectile density of 2.6 g/cc, and projectile diameter of 12.2 km to form the observed 200-km crater [6]. We use marine seismic and well data [7] to construct the sedimentary target in the downrange direction to the southwest of the crater, where it is formed from carbonates and evaporites. We assume incipient degassing at 60 ±20 GPa and full decomposition at 100 ±20 GPa for calcite [8], and incipient degassing at 30 GPa and full decomposition at 120 GPa for anhydrite [9-10]. In addition, we investigate the affect of submerging the sedimentary sequence by 1.5 km under water, as was the case to the NE of the crater [11] (Figure 1).

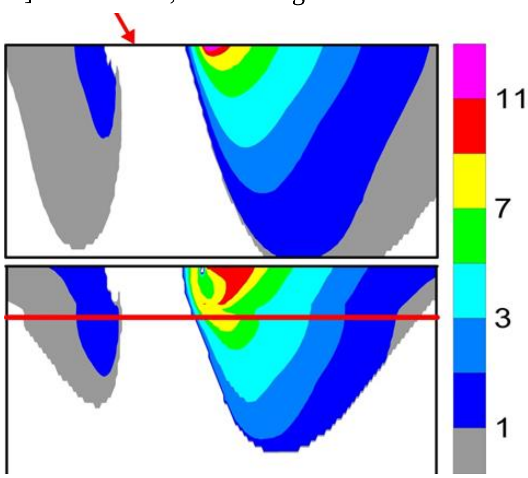

Fig. 1. Ejection velocities (color scale in km/s) in the plane of symmetry after a 60-degree impact into a sedimentary target (top) and covered by water (bottom, red line shows water depth). Red arrow shows impact point. The lengths of the X-and Y-axis are 10-times and 1-times the projectile radius, respectively, and equal to 60 and 6 km for Chicxulub (water depth 1.5 km).

Discussion: We note that, some previous models of released gases were over-estimated [1-2] as they were based on shock pressures determined during the first few seconds of impact, whereas here we model for over 30 seconds to ensure we capture which materials leave the impact site at > 1 km/s and, thus, have global consequences. In addition, assumptions of decomposition of calcite at 10-20 GPa [1-2] were based on the idea that porosity lowers the pressure at which devolatilazation occurs, but recent tests suggest this might not be the case when the pores are full of water [12].

References: [1] Ivanov B. et al. (1996) *Special Paper Geological Society America* 307:125-139. [2] Pierazzo E. et al. (1998) *Journal of Geophysical Research* 103:28607-28625. [3] Melosh H. J. (2007) *Meteoritics & Planetary Science* 42:2079-2098. [4] Collins G. S. et al. (2017) *LPS XLVII*, Abstract #1832. [5] Shuvalov V.V. (1999) *Shock waves*, 9:381-390. [6] Artemieva N. A. and Morgan J. V. (2009) *Icarus*, 201:768-780. [7] Bell C. et al. (2004) *Meteoritics & Planetary Science* 39:1089-1098. [8] Yang W. et al. (1996) *LPS XXVII*, 1473-1474. [9] Gupta S. C. et al. (2001) *Earth Planetary Science Letters* 188:399-412. [10] Prescher C. et al. (2011) *Meteoritics & Planetary Science* 46:1619-1629. [11] Gulick et al. (2008), *Nature Geoscience*, 1:131-135. [12] Kowitz A. et al. (2016) *Meteoritics & Planetary Science* 51:1741-1761.

Acknowledgments: ECORD implemented Expedition 364 with funding from IODP and ICDP. Artemieva was supported by NASA Grant 15-EXO15_2-0054 and Morgan by NERC Grant: NE/P005217/1.

[4]**Expedition 364 Science Party**: Elise Chenot, Gail Christeson, Philippe Claeys, Charles Cockell, Marco J. L. Coolen, Ludovic Ferrière, Catalina Gebhardt, Kazuhisa Goto, Sean Gulick, Heather Jones, David A. Kring, Johanna Lofi, Christopher Lowery, Claire Mellett, Joanna Morgan, Rubén Ocampo-Torres, Ligia Perez-Cruz, Annemarie Pickersgill, Michael Poelchau, Auriol Rae, Cornelia Rasmussen, Mario Rebolledo-Vieyra, Ulrich Riller, Honami Sato, Jan Smit, Sonia Tikoo, Naotaka Tomioka, Jaime Urrutia-Fucugauchi, Michael Whalen, Axel Wittmann, Long Xiao, Kosei Yamaguchi, William Zylberman.